Appendix H

Detailed Cost-Effectiveness Analysis of Passenger Ships

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This appendix contains a more thorough discussion of the cost-effectiveness analyses conducted for passenger ships than what was provided in Chapter VI. For brevity and clarity, Chapter VI addressed NOx emissions reductions for passenger ships burning 0.1 percent sulfur distillate fuel. Appendix H further addresses the reduction of other pollutants and the use of 0.5 percent sulfur distillate fuel.

For the other ship categories, staff determined the cost-effectiveness values for two specific scenarios: the necessary electrical transformers were constructed either at the port (shore-side) or on the ships (ship-side). For passenger ships, staff only considered shore-side transformers. The shore-side costs include a special dual-voltage transformer (6.6 or 11 kV), as most passenger ships use either of these voltages. This is the configuration used at both Juneau and Seattle for the Princess Cruises passenger terminals.

Furthermore, staff assumed labor costs for this category would be the same as that for container ships, with one exception; only two electricians, instead of three, would be used to hook-up and unplug passenger ships. Two electricians are currently being used for the ports in Juneau and Seattle. Staff assumed the same union rates for the electricians as with the container ships.

As with the other ship categories, for each port, cost-effectiveness values were determined for three scenarios: 1) all ships visiting the port are cold-ironed; 2) only ships that make three or more visits per year to a port are cold-ironed; and 3) only ships that make six or more visits per year to a port are cold-ironed. For the passenger ship category, staff also considered one-berth and two-berth scenarios for the six or more visit case. Electrifying one passenger-ship berth may capture most of the six or more visits; however, occasionally two frequent visitors are docked at the same time. The two-berth electrification includes the additional costs and emissions reductions for addressing these situations. The exception is the Port of Long Beach, which has only one berth for passenger ships.

Tables H-1 through H-4 show the “all pollutants” cost-effectiveness values for passenger ships visiting Long Beach, Los Angeles, San Diego, and San Francisco, respectively. At the Port of Long Beach, the group of ships that made three or more visits in 2004 also made six or more visits. Consequently, the cost-effectiveness values in Table H-1 for ships making six or more visits would also be the same for the ships making three or more visits.

Table H-1: All Pollutants Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Long Beach (Dollars/ton)		
Description	**Distillate Fuel (0.5% Sulfur)**	**Distillate Fuel (0.1% Sulfur)**
All Ships	$14,000	$15,000
Ships making 6 or more visits	$15,000	$16,000

Table H-2: All Pollutants Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Los Angeles (Dollars/ton)		
Description	**Distillate Fuel (0.5% Sulfur)**	**Distillate Fuel (0.1% Sulfur)**
All Ships	$37,000	$41,000
Ships making 3 or more visits	$20,000	$22,000
Ships making 6 or more visits		
--2 berths	$20,000	$23,000
Ships making 6 or more visits		
--1 berth	$14,000	$16,000

Table H-3: All Pollutants Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Diego (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
All Ships	$48,000	$54,000
Ships making 3 or more visits	$37,000	$42,000
Ships making 6 or more visits --2 berths	$27,000	$33,000
Ships making 6 or more visits --1 berth	$17,000	$19,000

Table H-4: All Pollutants Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Francisco (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
All Ships	$29,000	$34,000
Ships making 3 or more visits	$27,000	$31,000
Ships making 6 or more visits --2 berths	$33,000	$37,000
Ships making 6 or more visits --1 berth	$20,000	$23,000

Overall, as a ship category, passenger ships exhibit relatively low average cost-effective values, comparable to some container ships and reefer ships.

For Los Angeles and San Diego, the cost-effectiveness values decrease as fewer ships are cold-ironed. For the “all ships” scenario, four berths at both ports are cold-ironed. For the three or more visits scenarios, only two berths are cold-ironed, reducing the shore-side infrastructure costs, while eliminating the passenger ships that make one or two calls. Finally, the one-berth cost-effectiveness value for the six ships or more case assumes that the most attractive candidates will frequent that one berth. As with all other ship categories, high berth utilization is a strong influence on cost effectiveness.

For San Francisco, the cost-effective values are relatively flat until the one-berth, frequent-visitor scenario. For the “all ships” case, three berths are cold-ironed; otherwise, two berths are cold-ironed. San Francisco receives the fewest number of passenger ships among the four California ports analyzed, but the electrical rates are the lowest. Furthermore, there are more one-time visitors to San Francisco than to the other ports. All of these factors produce cost-effectiveness values that are relatively constant for the scenarios examined.

Tables H-5 through H-8 show the NOx reduction cost-effectiveness values calculated for the passenger ships at the four ports.

Table H-5: NOx Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Long Beach (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
All Ships	$16,000	$16,000
Ships making 6 or more visits	$17,000	$17,000

Table H-6: NOx Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Los Angeles (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
All Ships	$44,000	$44,000
Ships making 3 or more visits	$24,000	$24,000
Ships making 6 or more visits		
--2 berths	$25,000	$25,000
Ships making 6 or more visits		
--1 berth	$17,000	$17,000

Table H-7: NOx Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Diego (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
All Ships	$58,000	$58,000
Ships making 3 or more visits	$45,000	$45,000
Ships making 6 or more visits		
--2 berths	$33,000	$33,000
Ships making 6 or more visits		
--1 berth	$21,000	$21,000

Table H-8: NOx Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Francisco (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
<u>All Ships</u>	$36,000	$36,000
<u>Ships making 3 or more visits</u>	$34,000	$34,000
<u>Ships making 6 or more visits</u> --2 berths	$39,000	$39,000
<u>Ships making 6 or more visits</u> --1 berth	$24,000	$24,000

The use of low-sulfur or very low-sulfur distillate fuels has no impact on the NOx-only cost-effectiveness values, only PM and SOx.

Overall, the NOx-only cost effectiveness values for passenger ships are relatively low compared with other ship categories.

Tables H-9 through H-12 show the PM reduction cost-effectiveness values calculated for passenger ships at the four ports.

Table H-9: PM Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Long Beach (Dollars/ton)

Description	Distillate Fuel (0.5% Sulfur)	Distillate Fuel (0.1% Sulfur)
<u>All Ships</u>	$560,000	$560,000
<u>Ships making 6 or more visits</u>	$600,000	$610,000

Table H-10: PM Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of Los Angeles (Dollars/ton)		
Description	**Distillate Fuel (0.5% Sulfur)**	**Distillate Fuel (0.1% Sulfur)**
All Ships	$1,600,000	$2,600,000
Ships making 3 or more visits	$850,000	$1,400,000
Ships making 6 or more visits		
--2 berths	$880,000	$1,400,000
Ships making 6 or more visits		
--1 berth	$620,000	$1,000,000

Table H-11: PM Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Diego (Dollars/ton)		
Description	**Distillate Fuel (0.5% Sulfur)**	**Distillate Fuel (0.1% Sulfur)**
All Ships	$2,100,000	$3,500,000
Ships making 3 or more visits	$1,600,000	$2,600,000
Ships making 6 or more visits		
--2 berths	$1,200,000	$1,900,000
Ships making 6 or more visits		
--1 berth	$760,000	$1,200,000

Table H-12: PM Reduction Cost Effectiveness for Cold-Ironing Passenger Ships at the Port of San Francisco (Dollars/ton)		
Description	**Distillate Fuel (0.5% Sulfur)**	**Distillate Fuel (0.1% Sulfur)**
All Ships	$1,300,000	$2,100,000
Ships making 3 or more visits	$1,200,000	$2,000,000
Ships making 6 or more visits		
--2 berths	$1,400,000	$2,300,000
Ships making 6 or more visits		
--1 berth	$860,000	$1,400,000

As with the other ship categories, the average PM-only cost-effectiveness values are high because much of the diesel PM has been removed by using the cleaner fuel. Nevertheless, passenger ships still have lower PM-only cost-effectiveness values relative to other categories.

The prior analyses have all addressed *average* cost effectiveness. As mentioned before, when cold-ironing all ships, these average values include many ships that visit a few times and a few ships that visit many times. The following analysis will address the cost effectiveness of cold-ironing an incremental ship if the shore-side infrastructure is already in place.

Table H-13 provides the incremental cost-effectiveness values for NOx reductions only, PM reductions only, and "all pollutants" for passenger ships, using 0.1 percent sulfur distillate. The electrical rate used in the analysis assumed that cold-ironing activity was already occurring at the berth, reducing the impact of demand charges. In this case, staff used $0.22 per kW-hour.

Table H-13: Incremental Cost Effectiveness to Retrofit a Typical Passenger Ship Using Distillate Fuel (0.1% Sulfur) (Dollars/Ton)			
Visits	**NOx**	**PM**	**All Pollutants**
1	$72,000	$4,200,000	$67,000
3	$29,000	$1,800,000	$31,000
7	$19,000	$1,100,000	$18,000

Not surprisingly, the incremental cost-effectiveness values drop significantly with more visits made by a ship. At about three visits, the *incremental* cost-effectiveness values are similar to the *average* cost-effectiveness values discussed earlier, which are some of the lowest of any ship category. Although the passenger ships stay briefly in port—about 10 hours—their emissions are significant, making cold-ironing an attractive emissions reduction strategy.